THE STORY OF THE ELEMENTS

Potassium

(Part One)

May—June 1979

SARABHAI M CHEMICALS

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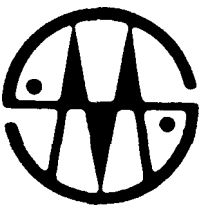
(Part One)



SARABHAI M CHEMICALS
BARODA

HISTORIC MILE-STONE

17th Century B.C. : Salt petre was being used for making glazes, In the lower Mesopotamia.

16th Century B.C. : Native sodium carbonate was used by the Egyptians for making glass.

15th century (1401–1410) : Potassium salts were being produced in Scotland from the ashes of seaweed.

Around 1790 : LAVOISIER, the *"father of chemistry"*, considered *Soda* and *potash* as compounds only and *not* as elements.

Around 1800 : KLAPROTH more particularly characterized between the *vegetable alkali* (potassium carbonate) and the *mineral alkali* (sodium carbonate), and termed them as *potash* and *soda,* respectively.

1807 : SIR HUMPHRY DAVY isolated potassim metal by electrolysis, for the *first* time.

1807 : SIR HUMPHRY DAVY coined the word potassium.

1808 : JOSEPH GAY-LUSSAC and LOUIS THENARD obtained potassium metal by reducing the hydroxide with iron.

1808 : F. R. CURAODAU prepared potassium by reducing potassium carbonate with carbon.

1839 : The Stassfurt deposits in Germany, became a basis for the German Chemical industry.

1854 : DEVILLE replaced potassium with sodium In the manufacture of aluminum.

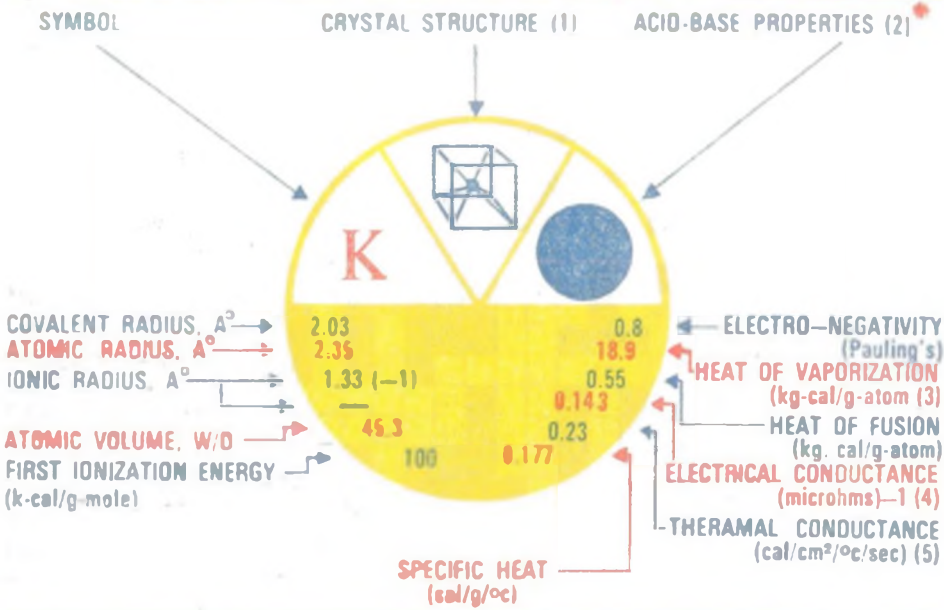
1860 : The recovery of potassium chloride from the *"rubbish salt"* in the stassfurt salt mines was started.

Around 1860 : LIEBIG and DUMAS showed the importance of potash – the largest natural resources – in Germany.

1914 – 1918 : The world's almost complete dependence on Germany for potash was dramatized by World War I.

After 1918 : Searles Lake, in California, was found to contain a sizable percentage of potassium salts.

PERIODIC PROPERTIES OF POTASSIUM



* Strong

Medium

Weak

(1) Cubic, body centered

(2) Oxides of Potassium are basic in character, and are indicated by dark blue colour. Intensity of colour indicates relative strength.

(3) At boiling point.

(4) From 0°C to 20°C

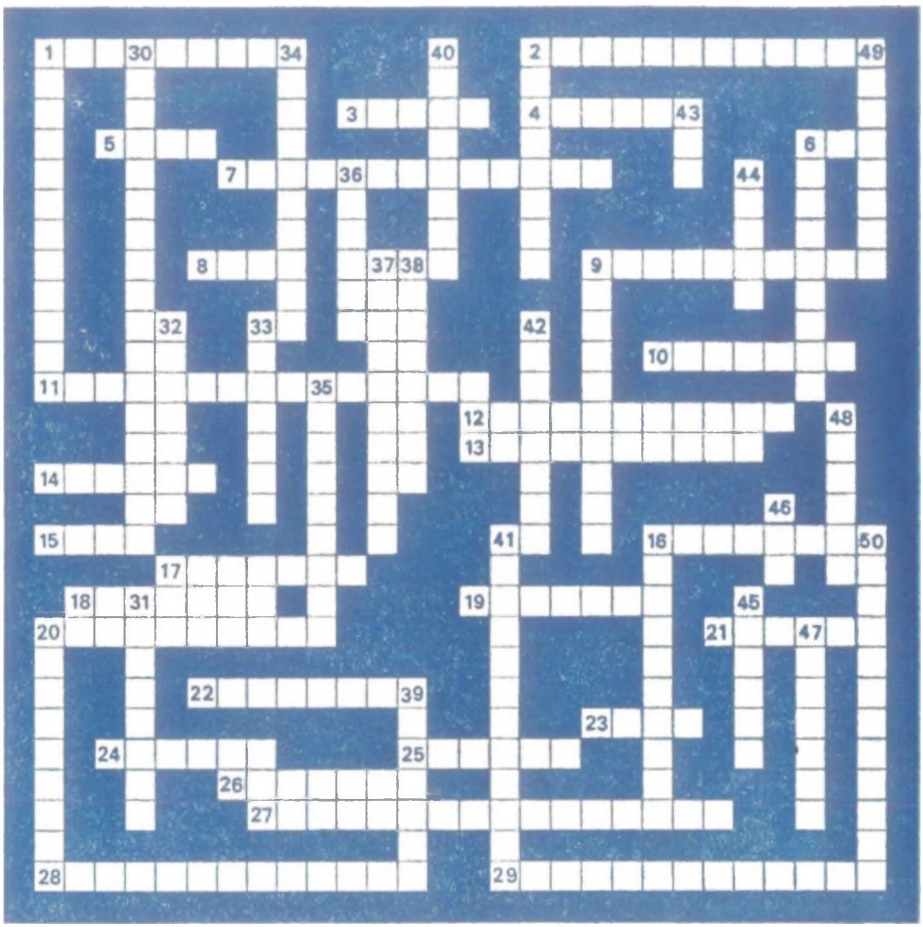
(5) At room temperature

(6) Ionic (crystal) radii for co-ordination number 6

(7) Metallic radii for co-ordination number of 12

Sarabhai M Chemicals

Chemistry Cross Word Puzzle (Potassium)

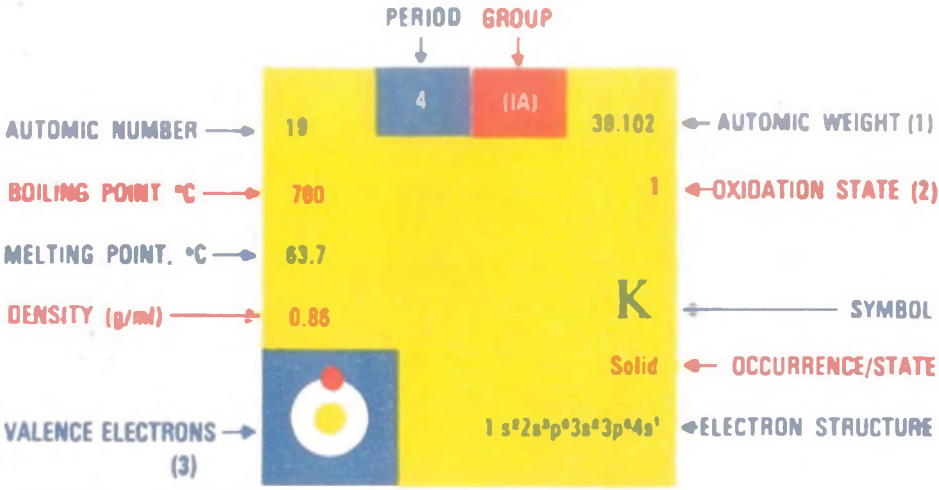


HORIZONTAL LEGEND

1. A silvery white metal with brilliant lustre. Member of the alkali metals family. Name coined by Davy from the Latinized version. (9)
2. A place in Canada, where occurs the largest deposits of potassium in the world. (12)
3. Scientist, who developed the method of estimating potassium in its compounds such as Silicates, Cements, Soils, Fertilizers, etc. (5)

(Continued on Page 6)

PHYSICAL PROPERTIES OF POTASSIUM



(1) Based upon Carbon-12.

(2) The element Potassium has one oxidation state : 1 which is most stable.

(3) Potassium has 1 valence electron in its outermost orbit.

Sarabhai M Chemicals

(Continued from Page 4)

4. Potassium ranks *seventh* in abundance, among all the elements in the earth's crust. Name the *first* most abondant element. (8)

5. The letter K is selected as a symbol for potassium from one Arabic word for *potash*. Name this Arabic word. (4)

6. A synonym for potassium hydroxide. (3)

7. Potassium carbonate is at present prepared from vegetable sources in different countries. Name such source utilized in Java. (7+6)

8. In Europe, potassium is known as *Kalium*, which is derived from an Arabic word. Name this Arabic word. (4)

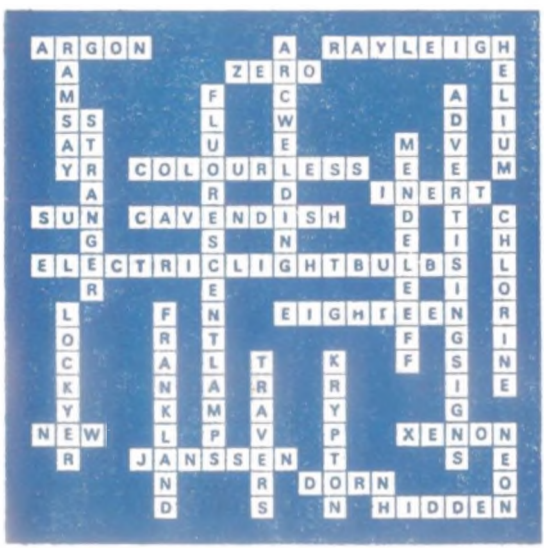
9. A separation method for separating potassium salts from their Ores. (10

10. Short *splints* of wood having a head that can be ignited by friction, used to kindle fire. Head comprises of potassium chlorate as one of the ingredients. Name these splints. (7)

11. Certain Western countries make potassium carbonate from vegetation sources. Tobacco stalks are used in Java. Name such source being used in Russia. (9 + 6)

12. A famous lake in california whose *brine* is said to be rich in potassium salts. (7 + 4)

(Continued on Page 19)



ARGON

Solution to the Chemistry Cross Word Puzzle
A R G O N
'The Story of the Elements'
"ARGON"

POTASSIUM

(Part One)

WITH AN ATOMIC NUMBER OF 19 AND AN ATOMIC WEIGHT OF 39.100, potassium, K, stands in the *middle* of the *alkali metal family,* below *sodium* and above *rubidium,* in Group I a and Period 4 of the Periodic Table of the Elements. The alkali metal family consists of lithium, sodium, *potassium,* rubidium, and cesium (plus francium, which is formed in some radio active decay processes and in nuclear reactions but all of whose isotopes have very short half-lives).

Potassium is a light weight, soft, low-melting, reactive metal. It is abundant and widespread in nature. In lithosphere, potassium comes seventh in order of abundance, just below sodium. In 1807, Sir Humphry Davy Isolated metallic potassium, by electrolysis, for the first time. It is very similar to sodium in its behaviour in metallic form, and its uses are limited as a consequence of the availability of low-cost sodium in large volume.

Potassium as a metal and in form of its alloys and salts, find applications in various disciplines of chemical industry. Most metallic potassium is used in the manufacture of potassium superoxide, KO_2, which, in turn is used in self-contained breathing equipment and gas masks. Next in importance is the potassium-sodium eutectic alloy. NaK, which has been used in nuclear reactors and some other applications. Potassium chloride finds its main use in fertilizer mixtures, It also serves as the raw material for the manufacture of other potassium compounds.

Potassium hydroxide is used in the manufacture of liquid soaps, and potassium carbonate in making soft soaps. Potassium carbonate is also an important raw material for the glass industry. Potassium nitrate is used in friction matches, in pyrotechnics, and in similar items which require an oxidizing agent.

Potassium is an essential constituent of living matter. In the organism, sodium and potassium perform vital function of maintaining fixed pH and water balance; sodium in combination with the bicarbonate Ion, is mainly extra-cellular, while potassium, in combination with chloride Ion, is within the cell.

DISCOVERY

Historical Background

THE HISTORY OF POTASSIUM IS CLOSELY LINKED to that of Sodium. Materials containing their compounds, particularly carbonates and nitrates, were known and used in some of the earliest civilizations. *Native sodium carbonate* was used by the Egyptians for making glass as early as the 16th century B.C.; records originating in Mesopotamia and dating from the 17th century B.C. mention the use of saltpetre for making glazes. However, the ancient technicians and artisans who used these materials,

Potassium is a constituent of many igneous rocks such as *feldspars orthoclase* and *microcline,* $KALSi_3O_8$, of the potassium *mica muscovite,* $H_2KAl_3(SiO_4)_3$; and of *leucite,* $KAl(SiO_3)_2$. It is found in soils and in the oceans, through the disintegration of minerals. Soils absorb potassium salts much more strongly than sodium sodium salts, so that less potassium finds its way into the sea; the potassium content of sea water is consequently much lower that its sodium content. Potassium also occurs in large secondary deposits of water-soluble salts formed by evaporation from inland seas. Such deposits contain : *Sylvite,* KCl; *carnallite,* $KCl.MgCl_2.6H_2O$; *Kainite,* $KCl - MgSO_4.3H_2O$; Picromerite, $K_2SO_4\ MgSO_4\ 6H_2O$; Syngenite, $K_2SO_4.CaSO_4.H_2O$ and polyhalite, $K_2SO_4\ MgSO_4.2CaSO_4.2H_2O$.

Potassium is an essential constituent of living matter. In the organism, sodium and potassium perform the vital function of maintaining fixed pH and water balance; sodium in combination with the bicarbonate ion, is mainly extracellular, while potassium, in combination with chloride, ion, is within the cell. Whereas plasma contains, per 100 ml, 300 mg of sodium and *only* 20 mg of a potassium, muscle tissue contains 80 mg of sodium and 320 mg of potassium. In plant material, potassium content is considerably higher than sodium content.

Potassium is not found in organic compounds in living tissues; it is found In plants only as the free ion. Its function has been defined, among others, in nerve cell, in heart muscle, and in enzyme action. Disturbances in Na/K ratio have serious effects. Potassium deficiency is associated with many common ailments, in which the usually ample normal intake of the ion is rendered insufficient by abnormal losses. The increasing use of prepared foods may also entail the leaching out of potassium, rendering them insufficient sources.

In plants, the means of absorption of potassium is uncertain; it is absorbed selectively over other ions such as sodium, calcium and magnesium. Potassium participates photosynthesis and respiration. Deficiencies lead to species-specific symptoms; typical are yellow and brown areas, or curling of the leaves, or weak stalks.

Potassium is also necessary for transmitting stimulation from nerves to muscles, and for the latter. In the liver it plays a part in the synthesis of glycogen from sugar (glucose); when the glycogen is decomposed, potassium is liberated again.

The relatively high content of the weakly radioactive K40 is often thought to be of great importance in various reactions taking place in the animal body.

After death, potassium diffuses away through the cell walls.

When too much potassium is taken up, the excess is quickly excreted again; 90% is excreted via the kidneys while the rest passes out with the faeces.

It is estimated that a man weighing 70 kg contains 160 g of potassium of which 157 g is present in the cells.

PROPERTIES

POTASSIUM BELONGS TO THE GROUP OF ALKALI metals (Group I of the periodic system) and closely resembles the other elements of the group : Lithium, Sodium, Rubidium, Cesium and the short-lived radio-active element Francium. Potassium is a reactive element and, therefore, its physical, chemical and radio-active properties play vital role in the applications of this metal.

Physical Properties

The *Physical Properties* of potassium metal are summarized in the Table 1. The *three colour* charts on pages 3 and 5 also depict these properties of the metal.

Chemical Properties

The chemistry of potassium is relatively simple; it has a valence of +1, it does not form complex ions and it is joined to other elements or groups of elements in its compounds by ionic bonds. Potassium is even more reactive than sodium.

Reaction with Oxygen

Potassium reacts vigorously with the oxygen in air to form the monoxide, K_2O, and the peroxide K_2O_2. In the presence of excess Oxygen, it readily forms the superoxide, KO_2 (formerly believed to be (K_2O_4).

having no knowledge of the chemical and physical methods of analysis and identification, did not distinguish between similar sodium, and potassium compounds. The terms used were often general and implied the source rather than the chemical content of the material. *Alkali* originally referred only to the material obtained from the ashes of plants, sodium and potassium carbonates. The term *Soda* of unknown etymology, was first applied to any alkali and later to the ash of sea plants. The term *Potash (pot-ash)* was applied to the ash of land vegetations, which generally contained a greater proportion of potassium carbonate.

The two alkalies, *soda* and *potash,* were successively designated as natural and artificial and as mineral and vegetable. In the first decade of the 15th Century, potassium salts were being produced in Scotland from the ashes of seaweeds. Finally in the 18th Century, after it was shown that the *"mineral alkali"* occured in the ashes of sea plants and the *"vegetable alkali"* in a number of minerals, the terms *soda* and *potash* were properly applied to specific substances. Since the chemical nature of these common alkalies had not yet been determined, they were belived by some to be elements. A. LAVOISIER did not include them in *his* list of elements, "because", he stated, these substances are evidently compounds, although however, the nature of the principles which enter into their composition is still unknown." This problem was finally solved in 1897 by the brilliant Young English Chemist, SIR HUMPHRY DAVY, who decomposed both the alkalies, obtaining the metals *Potassium* and *Sodium.* SIR HUMPHRY also coined the word – *"Potassium"* – as Latinized version of "potash".

OCCURRENCE

Potassium IS ABUNDANT AND WIDE SPREAD IN NATURE. Like Sodium, potassium does not occur naturally *in the free state.* However, in the form of compounds it is widely distributed. Potassium ranks *seventh* in order of frequency of elements in the earth's crust, that is, the surface of the earth to a depth of 10 miles.

The estimated order of frequency, and percentage, of the first ten elements is given below :

FREQUENCY OF THE COMMONEST TEN ELEMEMENTS

ORDER	1	2	3	4	5
ELEMENT	O	Si	Al	Fe	Ca
%	49.52	25.75	7.51	4.70	3.39

ORDER	6	7	8	9	10
ELEMENT	Na	K	Mg	H	Ti
%	2.64	2.40	1.94	0.88	0.58

Thus, potassium is almost as common as sodium, although the relatively greater frequency of sodium than potassium in salt deposits, and the general composition of the salt in sea water, leads to a common impression that sodium is much more plentiful. The estimated average content of *sodium* and *potassium* in ingenous rocks, in the three great classes of sedimentary rocks; in the shale, sandstone, and limestone, and in sea water, are as shown below :

PERCENTAGES OF SODIUM AND POTASSIUM IN MINERALS

	Sodium	*Potassium*
Indegenous rocks	2.85	2.60
Shales	0.96	2.40
Sand stones	0.33	1.00
Lime stones	0.04	0.25
Sea water	1.14	0.04

Thus, it appears that in the process of the Igneous rocks, leading to the formation of sedimentary rocks and the accumulation of soluble salts in the waters of the sea, potassium is retained in the rocks to a much greater extent than sodium, and, therefore, sodium accumulates in the soluble portion, in sea water, in much greater proportions.

WASHINGTON estimates that the *lithosphere,* i. e., the solid crust or the earth's crust, which amounts to 93%, is made up of 95% of igneous rock, 4% of shale, 0.75% of sand-stone, and 0.25% of limestone, whilst the *hydrosphere,* the aqueous portion, is 7% of the total.

TABLE-1 : PHYSICAL PROPERTIES

Property	Value
atomic weight	39.096
atomic number	19
density at 20°C	0.86
at 100°C	0.819
melting point, °C	63.7
boiling point, °C	760
crystal structure	body-centered cubic
important spectral line, Å	7664.9
ionization potential of gaseous atoms, V	4.32
specific heat, cal/g, solid	$0.1728 + 0.000142t^a$
liquid	$0.1422 + 0.000668t^a$
heat of fusion, cal/g	14.6
heat of vaporization, cal/g	496.0
viscosity at 250°C, cP	0.258
heat capasity at 200°C, cal/g	0.189
thermal conductivity at 200°C, cal/(sec) (Cm^2) (°C/cm)	0.107
Surface tension at 100°C, dyn/cm	86
electrical resistivity at 200°C, ohm-cm	21.85

[a] Where t is temperature in °C.

Reaction with Nitrogen

Potassium does not react with nitrogen to form a nitride.

Reaction with Hydrogen

With hydrogen, potassium reacts slowly at 200°C and rapidly at 350–400°C. It forms the least stable hydride of all the alkali metals.

Reaction with Water

The reaction between potassium and water or ice is violent, even at temperature as low as–100°C. The hydrogen evalved is usually ignited in

reaction at room temperature. Reactions with aqueous acids are even more violent and verge on being explosive.

Reaction with Carbon

Instead of forming the carbide with carbon, potassium forms a rather indefinite solid solution with the potassium atoms interposed between the layers of the graphite lattice.

Reaction with Halogens

Potassium reacts vigorously with the halogens. Lithium and sodium react only superficially with liquid bromine, but potassium detonates in contact with it. Potassium ignites in the reaction with iodine, also.

Reaction with Inorganic compounds

The reaction of potassim with amonia gives potassium amide, KNH_2, and hydrogen. Potassium differs from sodium in that an explosive carbonyl is formed when potassium reacts directly with carbon monoxide.

Reaction with Organic Compounds

Potassium reacts with many organic compounds, but not with saturated aliphatic hydrocarbons. With some aromatic hydrocarbons, metalation occurs, giving organo-potassium compounds. With acetylene, potassium acetylides are formed.

Potassium reacts with alcohols to form alkolides and hsdrogen. Most reactions of potassium with organic carbonyl compounds are very similar to those of sodium. In the form of NaK alloy, potassium is a very effective catalyst for the transesterification reaction involved in the commercial modification of lard.

Some important *Inorganic Reactions* of potassium are given in brief in *Table - 2.*

TABLE-2 : INORGANIC REACTIONS OF POTASSIUM

Reactant	Reactions	Product
O_2	fairly rapid	K_2O or KO_2
N_2, A, He	no reaction	
H_2	rapid reaction above 300°C	KH
H_2O	very rapid	KOH + H_2
C(400°C)	dissolves to solid solution, no carbide formed	potassium–graphite up to 40%K
NH_3	reacts easily	KNH_2
CO	forms carbonyl (sometimes explosive)	
S	in molten state	K_2S
CO_2	reacts	K_2CO_3 + reduction products
F	reacts violently	KF
Cl	reacts violently	KCl
Br	detonates	KBr
I	reacts–ignites	KI
H_2SO_4	explosive reaction	K_2SO_4
metal oxides and salts	reduction	free metal, potassium salts or oxides.

Radioactive Properties

Naturally occuring potassium consists of *three* isotopes of mass numbers 39, 40 and 41 with relative abundances 93.1%, 0.0119% and 6.9%, respectively. The least abundant isotope K^{40}, is radioactive with a half life of 1.2×10^9 years emiting *beta* (β) particles (electrons) :

$$^{40}_{19}K \rightarrow {}^{40}_{20}Ca + {}^{0}_{-1}e$$

and, to a lesser extent, gamma (γ) radiation.

$$^{40}_{19}K \rightarrow {}^{40}_{18}Ar + \gamma$$

Potassium belongs to the group of alkali metals (Group I of the periodic system) and closely resembles the other elements of the group, namely, lithium, sodium, rubidium, cesium and the short-lived *radio active* element francium.

MANUFACTURE

THE RAW MATERIAL FOR THE PRODUCTION OF metallic potassium, the potassium-sodium alloy, is potassium chloride. Potassium chloride is found to be occurring in *sylvite, sylvinite* (a mixture of potassium and sodium chlorides) and other salt deposits presumably formed by evaporation of *inland seas,* as well as in *brines, salt lakes,* the *Dead sea,* and other similar sources. These sources are exploited principally for fertilizer applications. For the production of potassium metal, the potassium chloride must be further purified by recrystallization.

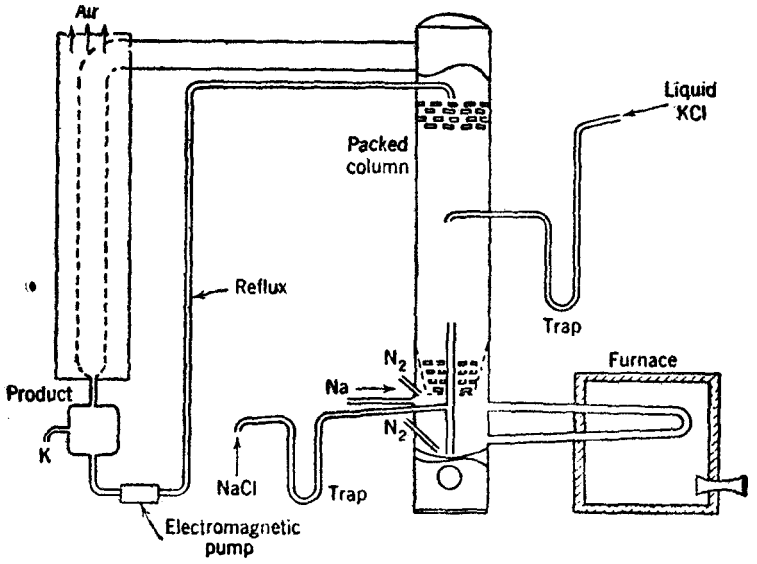
The simple electrolytic process used for the production of sodium metal-electrolysis of molten sodium chloride to which a little calcium chloride is added to lower the melting point-can not be used for potassium production. Unlike sodium, potassium attacks the graphite electrodes, which is not only undesirably in itself but also involves the added hazard of formation of explosive potassium carbonyls. Development of alternative electrode material is discouraged by the added circumstance that potassium metal and potassium chloride are miscible at temperatures above the melting point of the latter; again in contrast with sodium which floats on top of the electrolyte and can be skimmed off.

Potassium can be prepared by the electrolysis of molten potassium hydroxide; this was the reaction used by Davy in his experiments leading to the discovery of the metal, and it was used commercially in Germany but is now obsolete. The present process is the reduction of potassium chloride by sodium metal in a thermochemical reaction :

$$Na + KCl \rightleftharpoons K + NaCl$$

This is an equillibrium reaction, and is driven to the right by continuous removal of the reaction products.

One type of reactor is shown in *Figure 1.* During operation, the raw materials, molten sodium and molten potassium chloride, are introduced continuously. The sodium is vapourized in the boiler tubes and ascends the column, coming into contact with the descending liquid potassium chloride to establish the equilibrium mixture of the vapours of both sodium and potassium. Potassium is separated by fractionation in the upper part of the column, condensed, and collected. Under proper reaction conditions, all the potassium in the potassium chloride can be extracted. Metal of 99.5 + % purity can be produced, and by altering the reflux ratio and rates, any desired mixture of Na and K may result.



POTASSIUM CYCLE

POTASSIUM IS UNIVERSALLY PRESENT IN VEGETATION and in the animal body, its proportion in the total organism, and its proportion of the mineral, or ash content, varying widely. In general it is accompanied by sodium, but in most vegetations, the potassium is greater than the sodium, by a factor of 4–7.

In aquatic plants the butane balance may be rather more in favour of sodium but the potassium content is still high. The same applies to the proportion in the higher animals. Extensive data have been published in the past on the potash content of many individual plants and organic materials.

It is obvious that there occurs in nature a *'Potash Cycle'*. The weathering of igneous rocks gives rise to some potash in solution, and some adsorbed in the deposit which will give rise to sedimentary rocks. Some of the potash in solution may reach the sea, where that which survives the hazard of glauconitic precipitation goes to swell the salt content. But some of the aqueous potash produced by weathering, and some released to solutions from the sedimentary rocks, enter into plant life. By death and decay, this may return to the waters of the earth, to re-enter plant life or the sea, or be absorbed in the soil. Or from plant life the potash may enter the animal kingdom, once again by death and decay to be down graded. The forest of earth must represent very considerable reservoirs of potash circulating in the way. It has been suggested that tremendous reserves were built up in this way in the great forests of the Carboniferous period; the apparent absence of the potash in salt deposits which are known, of pre-carboniferous age, is due to the real absence of potash in pre-carboniferous seas. The death and decay of vegetation to which the coal measures bear witness liberated tremendous quantities of potash to the ocean, and hence rendered possible the potash containing deposits of the Permian and Tertiary.

(Continued from Page 6)

13. A mineral of potassium, which is extensively found in the Leucite Hills of the State of *Wyoming*, from which it takes its name. (10)

14. In Europe, potassium is known by a *Latin* word, which is derived from the Arabic term *Kali* or Qali. (6)

15. An English Chemist, who isolated the metallic potassium, by electrolysis, for the first time. He also coined the word *potassium* to the new metal (4)

16. The largest *aqueous* source of potassium chloride. Potassium content of this source comes to around 0 04%. (3+5)

17. A potassium mineral (K_2O, Al_2O_3, $4SiO_2$) occuring as extrusive masses in various parts of the globe, in very great quantities.)7)

18. A Country of Europe, which controlled the *entire* output of potassium chloride, *before* World War I. (7)

19. The famous sea whose brine is said to be rich in potassium content. (4+3)

20. A mineral of potassium, which is *very* wide-spread in its occurrence, but is rather *low* in potash content. (10)

21. A synonym for potassium carbonate. Davy coined the word *potassium*, which is the Latinized version of *this* particular word. (6)

22. A deposit or sediment formed in the bottom of wine casks during fermentation. It is found to be the recent source of potassium carbonate in France. (4+4)

23. A colourless, crystalline compound of potassium with strong *astringent* taste, used in dyeing, medicine, water-purification, etc. (4)

24. The *German* Scientist, who showed the importance of potash—the large natural resources—in Germany. (6)

25. The colour of the flame imported by potassium. (6)

26. The deadly poisonous compound of potassium. Mention only the negative radical. (7)

27. A disease of an adrenal gland disorder, which is caused by the potassium deficiency. (8+8)

28. The term *frequently* used for potash or potassium hydroxide. (7+6)

29. A synonym for potassium sodium tartrate, which is used as a diuretic and as a cathartic. (9+4)

VERTICAL LEGEND

1. Potassium nitrate was, many centuries ago, an important constituent of fire-works in China. Use a *synonym* for *fire-works*. (12)

20. In 1808, two scientists obtained potassium metal by *chemical reduction*. Name one of them. (3+6)

30. Name the *family*, in Periodic Table, which Potassium belongs to (6+5+6).

31. The *vertical* neighborer of potassium in the Periodic Table, which finds applications in photocells and in space-vehicles. (8)

32. The *only* horizontal neighbour of potassium in the Periodic Table. (7)

33. Two scientists prepared potassium metal by *chemical reduction*, in 1808. One was Joseph Gay-Lussdc. Name the other one. (7)

34. The *process* by which the body *uses up* and *replaces* its own substance in carrying on vital activities. Name this process. Potassium deficiency disturbs this body-function. (10)

35. A *synonym* for a potassium salt, which finds use in pyrotechnics, explosives, matches, fertilizer, solid rocket propellants, food preservative, etc. (9)

36. The largest potassium reserves are discovered in a country in the America continent. Name this country. (6)

37. The place in north Gujarat, whose sea brine contains 0.414% of potassium chloride. (10)

38. The *synonym* for a potassium compound which is used in the manufacture of special glasses (optical and colour TV tubes). (5+3)

39. The *order* of frequency of first ten elements in the earth's crust has been established. According to this order, oxygen comes at number *one* with abundance of 49.52% and Titanium at number *ten* with abundance of 0.58% which is the *order* of *frequency* of potassium ? (7)

40. The burning of wood to produce *ashes* which could be leached to produce a solution valuable for making soap was an *ancient* art. The term *potash* has come from this word. Name these *ashes.* (3+5)

2. A country of *Great Britain,* where potassium salts were produced from the ashes of sea-weed, in the 15th century. (8)

41. The process by which Sir Humphry Davy isolated metallic potassium, *for the first time,* in 1807. (12)

42. The scientist, who, in 1808, prepared potassium by reducing potassium carbonate with carbon. (8)

9. The *field* which consumes the *largest* quantity of potassium. [10]

10. A city in Germany, where the largest potassium deposits of Germany are located. [9]

43. Fertilizers containing *nitrogen, phosphorous* and *potassium.* Write the popular abbreviation. [3 or 1+1+1]

44. The *French* scientist, who showed the importance of *potash* — the largest natural source. [5]

45. The vertical neighbour of potassium in the periodic table, which is a soft, silvery-white metal. [6]

46. An important use of potassium is in the form of the alloy *with sodium.* Name this alloy. [2+1]

6. The French Chemist and the *"father of Chemistry"*, who *did not* consider these common alkalies : *Soda* and *potash* as elements. He treated them as compounds only. [9]

47. A *mineral,* which occurs widely, and which is considered as a very good source of potash, sulphuric acid and alumina. [7]

48. The German Scientist, who is remembered chiefly for his invention of the laboratory burner named *after* him. He also discovered Rubidium and Cesium. [6]

49. The atomic number of potassium. Write in words. [8]

50. The synonym for Seignette salt, which is used as a diuretic and as a cathartic. [8+4]

TO BE CONTINUED

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Bombay-400013 Gram : CHEMSAM.

CALCUTTA :
C. I. T. Road, Scheme LII, Entally (2/1/4 Deb Lane) P. B. No : 11208.
Calcutta-700014 Gram : CHEMSAM.

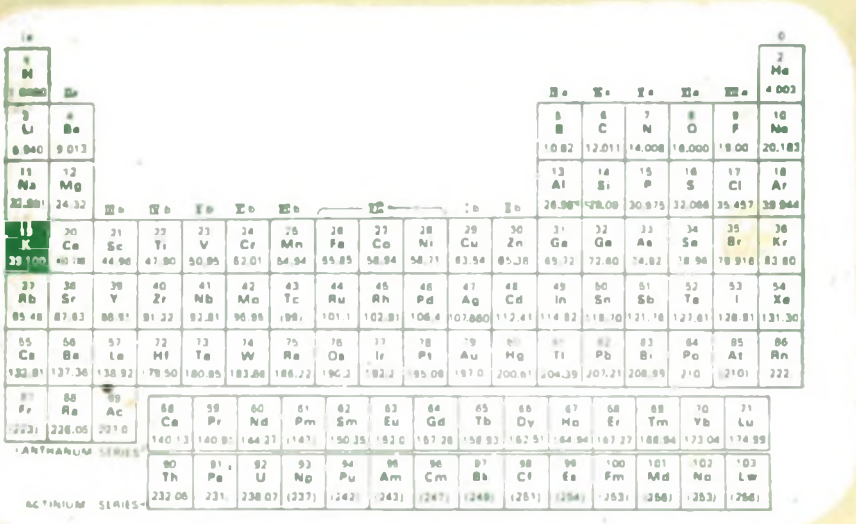
MADRAS :
123, Angappa Naicken Street, P. B. No : 1271
Madras-600001 Gram : CHEMSAM.

DELHI :
2E/25, Jhandewalan Extension, 1st Floor,
Delhi-110055.

THE STORY OF THE ELEMENTS

Potassium

(Part Two)



January-February, 1980

SARABHAI M CHEMICALS

THE STORY OF THE ELEMENTS

Potassium

(PART TWO)

SARABHAI M CHEMICALS
BARODA

POTASSIUM

(PART TWO)

DANGEROUS PROPERTIES, TOXICITY & HAZARDS

POTASSIUM IS A SOFT SILVERY METAL, TURNING GRAY ON EXPOSURE to air. Potassium metal enters into reaction with water, air and many other materials. Its handling, therefore, needs a special care. Potassium compounds, are however, non-toxic as to the action; any hazards are associated with the anion portion.

Toxic Hazards

Solid material causes severe skin and eye burns. Fumes from burning potassium are highly irritating to skin, eyes and mucous membranes. Wear protective clothing, goggles and self-contained breathing apparatus.

Toxic Hazards Rating

Acute Local

(1) IRRITANT : May cause death or permanent injury after very short exposure to small quantities.

(2) INGESTION : May cause death or permanent injury after very short exposure to small quantities.

(3) INHALATION : May cause death or permanent injury after very short exposure to small quantities.

Fire Hazards

Dangerous Exteremely dangerous in contact with moisture or water, releasing hydrogen with sufficient heat to cause ignition or explosion. The reaction involves much heat causing the potassium to melt and spatter. It also ignites the hydrogen which now burns, or if there is any confinement an explosion may occur. Burning potassium is difficult to extinguish. It can ignite spontaneously in moist air. Reacts violently with water, carbon dioxide or carbon tetrachloride.

Explosion Hazards

Moderate, by chemical reaction. Potassium metal will form the peroxide (K_2O_2) and the superoxide (KO_2 or K_2O_4) at room temperature even when stored under mineral oil. Metal which has oxidized on storage under oil may explode violently when handled or cut. Oxide coated potassium should be destroyed by burning.

Disaster Hazards

Dangerous ! A highly reactive alkali metal. In the presence of moist air, it can spontaneously catch fire and burn with great intensity. It may even explode. Reacts violently with moisture, acid fumes and oxidizers.

Radiation Hazards

Natural (0.12%) isotope ^{40}K, $T\frac{1}{2} = 1{\cdot}27 \times 10^9 y$. Decays to stable ^{40}A by ec (11%). Also decays to stable ^{40}Ca via β's of 13.2 MeV. Also via γs of 1.46 MeV and X-rays. Artificial isotope ^{42}K, $T\frac{1}{2} = 12{\cdot}4$ h. Decays to stable ^{42}Ca via βs of 2.00 (18%), 3.50 (82%) Mev. Also via γ's of 1.52 Mev

COUNTERMEASURES

Personal Protection

CAUSTIC POTASH (POTASSIUM HYDROXIDE) IS STRONG ALKALI. It destroys tissues owing to its solvent action on protein. It is particularly hazardous to eyes, and inhalation of dusts or mists can cause serious injury to the entire respiratory system. Depending on the degree of exposure, appropriate protective clothing, gloves, and eye protection should be used.

Skin contact should be followed promptly by washing with copious amounts of water. Eyes should be immediately flushed with water for atleast 15 minutes and medical attention should be obtained. Although the amounts commonly encountered by the analyst will be small, even a drop of a strong caustic solution can cause damage to or even the loss of an eye. Precautions are also advised while opening and sampling commercial shipments of solid or liquid caustic potash.

To a somewhat leasser extent, the same hazards, and therefore precautions, are indicated for potassium carbonate, which is also a fairly strong alkali.

Fire Fighting Phases

Do not use water, carbon dioxide or carbon tetrachloride. POTASSIUM REACTS VIOLENTLY WITH WATER, CARBON DIOXIDE AND CARBON TETRACHLORIDE. (In ordinary cases, these three are supposed to be good extinguishers), Use dry graphite, soda ash, powdered sodium chloride or appropriate dry powder. Wear proctective clothing and self-contained breathing apparatus.

STORAGE AND HANDLING

Storage

STORE IN AN INERT ATMOSPHERES, SUCH AS ARGON OR NITROGEN, or under liquids which are oxygen-free, such as toluene or kerosene, or in glass capsules which have been filled under vacuum or inert atmo-

sphere and sealed before oxygen or moisture can enter. When quantities of this metal are in use, provision should be made for fire-proof garments so that personnel can approach close enough to the fire to fight it.

Protect against physical damage. Store in dry place; protect against moisture and water. Separate from acids, metals, explosives, organic peroxides and easily ignitable materials.

Handling

Handling of potassium metal is much the same as that of sodium metal with two major exceptions. First, the formation of the superoxide, KO_2, causes difficulties because it can react vigorously with hydrocarbons and other organic matter. Second, potassium is generally more reactive than sodium. Potassium forms an explosive carbonyl with carbon monoxide, and the metal detonates in contact with bromine.

Generally, sodium, potassium and the sodium-potassium (NaK) alloys are considered to be in the same general class of reactivity, allowing for the chemical differences outlined above and for the liquid (and hence more reactive) nature of the NaK alloys over a wide composition range. Large quantities of potassium can be disposed of by simply cutting it into small pieces and placing it in an open waste space to react with the moisture in the air and gredually turn to potassium hydroxide. Potassium may be reacted with ethanol to give a stable product. De not dispose of it, even in small quantities, by throwing it into sinks or waste containers which may contain combustible materials. It should be stored in a detached building which is fire-proof and not where it can come in contact with moisture, powerful oxidizing materials or high temperatures.

PHARMACOLOGY

THE PRINCIPAL SALTS AND PREPARATIONS OF POTASSIUM USED in medicine are the following :

Potassium acetate has been recommended in cardiac arrhythmias, *potassium arsenite* solution (Fowler's solution contains 1% of arsenic trioxide) for chronic myelogenous leukemia and psoriasis. *Potassium bicarbonate* is used as antacid and to alkalize urine. *Potassium bitartarate* (cream

of tartar) has been used as a dusting powder and laxative; large doses can cause renal damage. *Potassium bromide* is used as a sedative and as an antiepileptic. *Potassium chlorate* has been used as an astringent in conditions such as stomatitis and vincient's angina, *Potassium dichromate* has been used externally as an astringent, antispeptic and caustic; industrial contact may result in ulceration of the hands and destruction of mucous membranes; internally it is a corrosive poison. *Potassium glycerophosphate* has been used as a tonic. *Potassium guaiacolsulphonate* (thiocal: orthocol) has been recommeneded as an expectorant. *Potassium hydroxide* is occasionally used as a caustic; it is extremely corrosive, *Potassium permanganate* is used as an astringent, antiseptic and oxidizing agent in 1:100 to 1:10,000 soultions; toxic symptoms include emesis, profuse salivation, rapid respiration and albuminurea. *Postassium phosphate,* monobasic is used to acidify urine; large doses are cathartic. *Potassium sodium tartrate* (Rochelle salt or Seignette salt) is used as a diuretic and as a cathartic. *potassium sulphate* is used as a cathartic; it is a powerful irritant, excess doses of which may be fatal. *Potassium tartrate* (soluble tartar) has been used as a catharic.

APPLICATIONS

POTASSIUM METAL FINDS APPLICATIONS IN A VARIETY OF FIELDS. The greater part of the productoin of metallic potassium is used in the manufacture of potassium superoxide, KO_2.

Potassium Alloy

The next most important use of potassium is in the form of the alloy with sodium, NaK. NaK (78%K) has been used as a heat transfer fluid in some nuclear reactors, and in some other applications. With its boiling point of 1446°F, and its low vapour pressure of 0.46 psia at 950°F, it has outstanding properties for high-temperature uses.

NaK system is used to supply heat or to remove heat. A system employing 40,000 lb of NaK removing heat from a reactor at 850°F has been placed in commercial service in a chemical plant. Heat-transfer systems feature electromagnetic pumps and flow meters, which have no moving parts, a definite advantage at high temperatures.

Nak is also used as a replacement for liquid water for heat transfer in consumable electrode furnaces for processing high-melting reactive metals, where its use is safer than the use of water, which can react explosively with the reactive metals in the event of a leak in the cooling system. In addition to the safety aspect, the use of NaK allows recovery of ingots that would normally be lost in the event of even a small-scale leak were the system using water as the coolant. Because NaK is less expensive than mercury, it is finding use in low-temperature applications as a replacement in heating controls, electrical contacts, and the electromagnetic control of valves.

NaK is used as liquid-metal brushes in homopolar generators as a source of very high current and low voltage. Four of these acylic generators, each rated at 5,55,000 A and 45 V, are in service at the U.S. Air Force's Arnal Engineering Development Center, Tullahoma Tennessee.

Another important use of NaK is as a scavenger for impurities in non-rective gases and liquids. Inert gas purifiers employing NaK as a scavenger for impurities have been used for many years, and are now available commercially as recirculating models for glove-box applications. Inert gases can be purified to less than 1 ppm water content and less than 1 ppm oxygen content.

In some chemical applications, either NaK or pure potassium can be used.

Car load quantities of NaK were used from 1957 to 1964 as a transesterification catalyst.

The use of NaK permits the mixed glyceride esters of lard to be rearranged in a controlled manner to a more desirable mixture of fats than occurs naturally or than can be attained by random rearrangement.

Potassium Reagents

Reagents derived from potassium metal find many uses in Organic Syntheses involving condensations, dehalogenations, reductions, and polymerizations.

Potassium Superoxide

Potassium superoxide, KO_2, is used in self-contained breathing equipment. The exhaled air is held within the device where it is contacted with a bed of KO_2. Moisture in the exhaled air leads to complete decomposition of the KO_2, while CO_2 is absorbed by the resulting KOH. This breathing equipment is used extensively for rescue and fire-fighting purposes, by the armed services and by civilian agencies. This type of life support system is also of interest in space and undersea exploration.

Potassium Metal

Potassium metal may find application as a seed material in **magneto-hydrodynamic** (MHD) power plants for the conservation of heat directly to electricity or for use in topping conventional steam plants to increase efficiency of fuel use. Efficiency migh tbe increased from a possible maximum of 45% attainable through extensive development of conventional steam plants to a suggested 65% maximum through use of ionized in magnetic fields to generate power preceding the conventional steam-turbine method of making power. Other power-generating MHD Systems not associated with conventional power plants may employ potassium metal or metal-derived salts as a seed material.

Another MHD concept using potassium metal is reported under development at Atomics International, Division of North American Rockwell Corporation. Potassium is heated to 1600°F in furnaces and then introduced into a drift tube where it reaches speeds of up to 400ft/sec. The conductive potassium liquid flowing in a magnetic field generates power. The company is planning a pilot plant with an MHD generator with an out-put of 1-2 KW electrical power.

Potassium Compounds

Potassium compounds are being used since antiquity. Potassium compounds occur naturally almost in all parts of the world. In addition, many compounds are synthesized too. Some important compounds are discussed in a separate chapter. The applications of potassium compounds are discussed under individual headings.

COMPOUNDS

POTASSIUM COMPOUNDS WERE USED IN antiquity. Potassium carbonate was leached from ashes in Pompeii and "strengthened" with line (converted to the hydroxide) for soap-making. The increase in the use of alkali paralleled the growth of western civilization and so much wood was consumed in its production that the forests of Europe were being threatened when LeBlanc's invention led to the general substitution of sodium carbonate at the time of the French Revolution.

The Chines, to make gunpowder centuries ago, obtained pottassium nitrate by leaching soil where nitrogen from urine had combined with mineral potassium. Later Europeans did the same, and by the time of the Napoleonic Wars, this potassium nitrate was a strategic material and was still obtained from the same source, primarily from India. Many of the nineteenth century "fathers of chemistry" were involved in the manufacture of gunpowder.

The usefulness of potassium compounds as fertilizers had been shown in experiments, but their effects are not as striking as those of nitrogen compounds for instance, and essentially none were used as such before the recovery of potassium chloride from the " rubbish salt " in Stassfurt salt mines was started in 1860. This cheap potash not only displaced most other sources of supply of existing uses, but its aggressive exploitation led directly to the creation of a world-wide potassium fertilizer market. Now, 90% of potash production is used in fertilizer.

The " potash " of course originated when the product was leached from ashes (=pot-ashes). When the chloride became the prime potassium compound, it was also called potash, and now term is frequently applied to other potassium compounds that are used in quantity.

The world's almost complete dependence on Germany for potash was drammatized by World War I and this resulted in the development of many marginal and new sources. Today Germany has less than 25% of the World's commercial capacity, and with the recent discovery of immense new reserves in Canada, the European deposits will diminish its importance.

Potassium is the seventh most abundant element in the earth's crust about equal to sodium, and potassium compounds occur naturally in all parts of the world.

Potassium compounds are often specified as analytical laboratory reagents. This is partly due to tradition : during the period when analytical chemistry was being systematized in Europe, potassium compounds were more available than sodium owing to the large stassfurt deposits. In many instances also the potassium salts are more readily crystallized and purified.

Potassium Acetate

Potassium acetate, CH_3COOK, is a white crystalline, deliquescent powder with saline taste. It is soluble in water and alcohol, and insoluble in ether. It is made from potassium carbonate and acetic acid.

It is used in the manufacture of crystal glass, as a buffer, and in medicine as a diuretic and urinary alkalizer, and a source of potassium ion. Its deliquescent properties make it useful as a softening agent for papers and textiles. It is an usual reagent in analytical reagent.

Potassium Alginate

Potassium alginate, $(C_6H_7O_6K)_n$ is a hydrophillic colloid having a molecular weight of 32,000 to 2,50,000. It occurs in filamentous, grainy, granular, and powdered forms. It is colourless or slightly yellow and may have a slight characteristic smell and taste. It is slowly soluble in water forming a viscous solution; and insoluble in alcohol.

Sodium alginate is used as a thickening agent and stabilizer in dairy products, canned fruits and sausage casings. It is also as used as an emulsifier.

Potassium Aluminate

Potassium aluminate, $K_2Al_2O_4 . 3H_2O$, is a hard crystalline, lustrous solid. It dissolves in water with hydrolysis to form strongly alkaline solution; and is insoluble in alcohol. It is produced by fusing caustic potash with alumina.

It has some applications in dyeing and printing (mordant); lakes and paper sizing.

Potassium Bicarbonate

Potassium bicarbonate, $KHCO_3$, is a colourless, odourless, transparent crystalline material or white powder having slightly salty taste. It is slightly soluble in water and potassium carbonate solution, and insoluble in alcohol. It is prepared by passing carbon dioxide into a solution of potassium carbonate in water.

It is used in baking, soft drinks, and low pH detergents; as an antacid, urinary alkalizer, and source of potassium ion in medicine. It is twice as effective as sodium bicarbonate in dry powder fire extinguishers. It is used in the manufacture of pure potassium carbonate. It is a common laboratory reagent.

Potassium Bromide

Potassium bromide, KBr, is white, crystalline granules or powder, with pungent, strong, bitter, saline taste. It is somewhat hygroscopic and is soluble in water and glycerin, but slightly soluble in alcohol and ether.

Solutions of iron bromide and potassium carbonate are mixed and heated, the solution filtered and concentrated and the bromide crystallized out :

$$Fe_3Br_8 + 4K_2CO_3 \longrightarrow 8\,KBr + 4\,CO_2 + Fe_3O_4$$

It is also prepared by the reaction of bromine with a solution of potassium carbonate :

$$3\,K_2CO_3 + 3\,Br_2 \longrightarrow 5\,KBr + KBrO_3 + 3\,CO_2$$

Potassium bromide finds uses in photography (gelatin bromide papers and plates) and in process engraving and lithography. It is a common source of bromine in Organic Synthesis. It was a classical sedative in medicine, but medical uses of bromides are decreasing to relative unimportance with the development of improved drugs that avoid their side-effects. It is used as a solvent in Infra-red spectroscopy.

Potassium Carbonate

Potassium carbonate is one of the more important compounds of potassium. It is also known as pearl ash or potash. Historically, it is the earliest source of potassium and its primitive method of manufacture, the leaching of pot-ashes, gave the common generic name to the entire family of chemicals. Today, in industry potassium chloride, potassium carbonate and potassium oxide may all be called "potash" and potassium hydroxide is "caustic potash".

Potassium carbonate, K_2CO_3, is a white, deliquescent, granular, translucent powder. It is soluble in water and insoluble in alcohol.

Potassium carbonate may be manufactured by several routes, the choice of which depends more on economic and market factors than technology. (1) Engel–Precht process uses magnesium oxide, potassium chloride, and carbon dioxide, separating the Engels salt ($MgCO_3.KHCO_3, 4H_2O$). Decomposition leaves potassium bicarbonate in solution which can be processed to potassium carbonate. (2) Alkyl amines or ion–exchange resins can be used with potassium chloride and carbon dioxide to yield potassium bi-carbonate, which is calcined to the carbonate. This is analogous to the Solvay process for sodium carbonate. (3) The electrolysis of potassium chloride gives chlorine and potassium hydroxide; the latter, when treated with carbon dioxide, yields potassium carbonate.

The principal use of potassium carbonate is in the manufacture of special glass (such as optical and colour TV tubes). It is the usual starting point for the preparation of other potassium salts, by reaction with the appropriate acid. It is considerably soluble than sodium carbonate. Its other uses include potassium silicate, dehydrating agent, pigments, printing inks, soft soaps, raw wool washing, general purpose food additive, etc.

Potassium Chlorate

Potassium chlorate, $KClO_3$, is transparent, colourless crystals or white powder having cooling, saline taste. It is soluble in water, alkalies and alcohol. It is made (a) by electrolysing a hot concentrated alkaline soluble solution of potassium chloride, or preferably (b) by interaction of solutions of potassium chloride and sodium chlorite or calcium chlorate.

Potassium chlorate is a strong oxidizing agent. Moderately toxic; flammable. It forms explosive mixtures with combustible material (sulphur, sugar, etc). Potassium chlorate is employed in various fields, which include: explosives, matches, textile printing, pyrotechnics, percussion caps, medicines, dyes, paper manufacture, disinfactant, bleaching, etc. It is also used as a source of oxygen and as an oxidizing agent in synthesis.

Potassium Chloride

Most potassium compounds are obtained from natural sources as the chloride, which is, therefore, the starting point from which other compounds are derived.

Potassium chloride, KCl, is a colourless or white crystalline substance with strong saline taste. It occurs naturally as sylvite. It is soluble in water; slightly soluble in alcohol; and insoluble in absolute alcohol.

It is (a) mined from sylvite deposits in New Mexico and Sasketchewan, purified by fractional crystallization or floatation; or (b) extracted from salt lake brines, and purified by recrystallization. Potassium chloride is the form usually used as fertilizer. For other uses, the natural purified to various degree. Potassium chloride serves as a good source of potassium salts. Its other uses include : pharmaceutical preparation, photography, spectroscopy, plant nutrient, salt substitute and laboratory reagent.

Potassium Cyanide

Potassium cyanide, KCN, is white, amorphous, deliquescent lumps or crystalline mass with faint odour or bitter almonds. It is soluble in water, alcohol and glycerol. It is derived by absorbing hydrocyanic acid in potassium hydroxide. It is highly toxic and is absorbed by skin. It is a reagent in analytical chemistry. It is used in the extraction of gold and silver from ores. It is also used in the manufacture of various intermediate organic cyanogen derivatives. Insecticides and fumigants are the other applications of this deady poisonous material.

Potassium Dichloroisocyanurate

Potassium dichloroiso cyanurate, $Cl_2K(NCO)_3$, OCNCICONCICONK, is a cyclic compound. It is white, slightly hydroscopic, crystalline powder or

granules. It contains as an active ingredient approx 59% available chlorine.

It has many applications, such as, household dry bleaches, dishwashing compounds. Scouring powders, detergent-sanitizers, and replacement for calcium hypochlorite,

Potassium Dichromate

Potassium dichromate, $K_2Cr_2O_7$, is a bright yellowish red transparent crystalline substance with bitter, metallic taste. It is a soluble in water and insoluble in alcohol. It is derived by adding sulphuric acid to crude potassium chromate solution. Toxic by ingestion and inhalation. Dangerous fire risk in contact with Organic materials. Very strong oxidizing agent.

It has a wide range of applications, to give a few : oxidizing agent (chemicals, dyes, intermediates) analytical reagent, brass pickling compositions, electroplating, pyrotechnics, explosives, safety matches, textiles, dyeing and printing, glass chrome glues and adhesives, chrome tanning leather, wood stains, poison fly paper, process engraving and lithography photography, pharmaceutical preparations, synthetic perfumes, chrome alum manufacture, pigments, alloys and ceramic products.

Potassium Ferricyanide

Potassium ferricynide $K_3Fe(CN)_6$, is bright red, lustrous crystals or powder. It is soluble in water and slightly solble in alcohol. It is prepared by passing chlorine into a solution of potassium ferrocyanide, the ferricyanide separating out.

Its fields of applications are : tempering steel, etching, liquid, production of pigments, electroplating, sensitive cotatings on blueprint paper, fertilizer compositions, and laboratory reagent.

Potassium Ferrocyanide

Potassium ferrocyanide, $K_4Fe(CN)_6 \cdot 3H_2O$, is lemon yellow crystals or powder having mild saline taste, It effloresces on exposure to air. It is soluble in water and insoluble in alcohol. It is prepared from nitrogenous waste products, iron fillings and potassium carbonate. On heating to red heat it evolves highly toxic fumes, but as such the compound itself has low toxicity.

Its fields of applications are : medicine, potassium cyanide and potassium ferricyanide, dry colours, tempering steel, dyeing, explosives process engraving and lithography, laboratory reagent, etc.

Potassium fluoride

Potassium fluoride, KF, is a white, crystalline, deliquescent powder with sharp saline taste. It is soluble in water and hydrofluoric acid and insoluble in alcohol. It is prepared by saturating hydrofluoric acid with potassium carbonate. It is toxic by ingestion and inhalation; strong irritant to tissue.

It finds applications in glass etching, in preservatives, in insecticides and in the production of fluorine.

Potassium Glycerophosphate

Potassium glycerophosphate, $K_2C_3H_5O_2.H_2PO_4.3H_2O$, is a pale yellow, syrupy liquid with acid taste. It is soluble in alcohol, and miscible with water in all proportions, Nontoxic.

It is prepared by the following method : Glycerol and phosphorus pentoxide or metaphosphoric acid are mixed, warmed and exactly neutralized with potassium carbonate, warmed and concentrated.
It is a food–additive and a good dietary supplement.

Potassium hydrogen phthalate

Potassium hydrogen phthalate, $HOOCC_6H_4COOK$, is a colourless, crystalline substance. It is soluble in water. It is derived from potassium hydroxide and phthalic anhydride.

Potassium hydrogen phthalate is of no commercial importance, but its importance in analytical chemistry derives from its use as the principal primary standard for acidometry, alkalimetry and also as a pH standard.

Potassium Hydroxide

Potassium hydroxide, KOH, is white, deliquescent pieces, lumps, sticks, pellets, or flakes having a crystalline fracture. It is soluble in water, alcohol and glycerin and slightly soluble in ether. It readily absorbs water and carbondioxide from the air. Toxic by ingestion and inhalation; strong irritant to tissue.

It is prepared by the electrolysis of concentrated potassium chloride solution.

Much of the potassium hydroxide produced is used in the manufacture of soft soap; this is used in liquid soaps and other detergent specialities. Textile applications, dyestuffs, liquid fertilizer, food additives, herbicides, greases, catalysts; engraving, lithography and rubber fabrication consume significant amounts, and it is the electrolyte in alkaline batteries. It is also used in the manufacture of potassium carbonate and tetrapotassium pyrophosphate.

Potassium Iodate

Potassium iodate, KIO_3, is a white crystalline powder. It is odourless. It is soluble in water, sulphuric acid (dilute); and insoluble in alcohol. Low in toxicity.

Potassium iodate, is used in analytical chemistry in testing of zinc and arsenic and also in iodometry. Medicine, reagent, feed additives are some fields where it is consumed in good quantity. Food industry consumes it as a maturing agent and dough conditionar.

Potassium Iodide

Potassium iodide, KI, is white crystals, granules or powder with strong bitter saline taste. It is soluble in water, alcohol, acetone and glycerol. Low in toxicity.

It is made by absorbing iodine in potassium hydroxide :

$$3I_2 + 6KOH \longrightarrow 5KI + KIO_3 + 3H_2O$$

Principal uses of potassium iodide are in animal and human food, pharmacy, and photography. It is classified by USP as an expectorant. It is a reagent in analytical chemistry. Spectroscopy, infra-red transmission and scintillation are the other fields which consume a considerable amount of potassium iodide.

Potassium Metabisulphite

Potassium metabisulphite, $K_2S_2O_5$, is white granules or powder with sharp, pungent odour. It oxidizes in air and moisture to sulphate. It is slightly soluble in water and alcohol. Low in toxicity it is prepared by heating potassium bisulphite until it loses water.

Potassium metabisulphite finds applications in brewing (cleaning casks and vats), and in wine making (kills only undesirable yeasts and bacteria). It is antiseptic, antioxidant and a food preservative. In analytical chemistry it is used as a reagent. Photography (developing agent) process engraving and lithography, and dyeing also use a good quantity of potassium metabisulphite.

Potassium nitrate

Potassium nitrate or salt petre, KNO_3, is transparent, colourless or white crystalline powder or crystals. It is slightly hygroscopic, having slightly hygroscopic, having slightly pungent saline taste. It is soluble in water; and slightly soluble in alcohol and glycerin. Low in toxicity.

Dangerous fire and explosion risk when shocked or heated, or in contact with organic materials. Strong oxidizing agent.

At one time, potassium nitrate was derived from Chilean nitrate deposits, or made by the following reaction :

$$KCl + NaNO_3 \longrightarrow KNO_3 + NaCl$$

The availability of inexpensive nitric acid from ammonia plants has made nitric acid the preferred source of the nitrate (NO_3^-) ion : the reaction between nitric acid and potassium chloride is complicated by the formation of nitrosyl chloride and chlorine, and condition must be carefully controlled; the overall reaction, including the oxidation of ammonia, is :

$$4KCl + 4NH_3 + 9\ O_2 \longrightarrow 4KNO_3 + 2\ Cl_2 + 6\ H_2O$$

Potassium nitrate is used for fertilizer, in pyrotechnics, in glass manufacture, as a food preservative, and occasionally in explosives. The eutectic with sodium nitrate and sodium nitrite has a mp of 142°C and is used in heat treating steel. Potassium chlorate is also used to modify the burning properties tobacco. It works as an oxidizer in solid rocket

propellants. Anaphrodisiac, colour fixative in meat, matches, specialty tobacco, glass manufacture and metallurgy also consume certain amount of potassium nitrate.

Potassium nitrite

Potassium nitrite, KNO_2, is white or slightly yellowish prisms or sticks, deliquescent in nature. It is soluble in water and insoluble in alcohol. Dangerous fire and explosion risk when shocked or heated, or in contact with Organic materials. Strong oxidizing agent. It is made by absorbing oxides of nitrogen in a solution of potassium carbonate.

Potassium nitrite in analysis (testing for amino acids, cobalt, iodine, urea). Besides this, it is also used in medicine and organic synthesis.

Potassium penicillin G

Potassium penecillin G, $C_{16}H_{17}KN_2O_4S$ is colourless or white crystals or powder. It is an odourless, moderately hygroscopic substance. It is relatively stable. It dissolves freely in water, in saline and in dextrose solutions, but moderately soluble in alcohol. Its solutions are dextro-rotatory; and pH of solution (30mg/ml) in 5,0-7,5.

Potassium penicillin G is used in medicine.

Potassium persulphate

Potassium persulphate, $K_2S_2O_8$, is white crystals; soluble in water, but insoluble in alcohol. Moderately toxic, strong irritant and oxidizing agent. Dangerous fire risk in contact with organic materials. It is derived by electrolysis of a saturated solution of potassium sulphate.

Potassium persulphate is employed in various fields : bleaching, oxidizing agent, reducing agent in photography, antiseptic, soap manufacture, analytical reagent, polymerization promoter, pharmaceuticals, modification of starch, flour-maturing agent and desizing of textiles.

Potassium permanganate

Potassium permanganate, $KMnO_4$. is a dark purple crystalline substance with blue metallic sheen. It has no odour but has sweetish, astringent taste. It is soluble in water, acetone and methanol, but gets decomposed by alcohol.

Toxic by ingestion and inhalation; strong irritant to tissue. Dangerous fire risk in contact with organic materials. Powerful oxidizing agent.

Potassium permanganate is prepared by the following methods : (a) By oxidation of the manganate in an alkaline electrolytic cell. (b) A hot solution of the manganate is treated with carbon dioxide ; on cooling, the solution deposits crystals of the permanganate.

It is a powerful oxidizer, disinfectant and deodourizer. It acts as a reagent in analytical chemistry, as an oxidizing agent in the manufacture of organic chemicals, and in air and water purification.

Potassium silicate

Potassium silicate is colourless, anhydrous lump, shattered or granular. It is soluble in water only at elevated temperatures and pressure. (solution) colourless liquid. Weight ratio $SiO_2 : K_2O$ varies with grade, as 2.1:1; 2.5:1. Be' range : 29–48°.

It is derived from supercooled melt of potassium carbonate and pure silica sand. It is also prepared from sodium silicate by using ion-exchange resins.

Solid potassium silicate is used in the manufacture of glass and refractory material, welding rods and potassium silicate solution. Solution of potassium silicate finds applications as nonefloresecing base for inorganic protective coatings, as coating for roofing granules and welding rods. It is also used as a binder in the manufacture of carbon arc–light electrodes and for phosphorus on television tubes. Detergents, catalysts and adhesives also use some quantity of potassium silicate.

Potassium sulphate

Potassium sulphate K_2SO_4, is colourless or white, hard crystals or powder with bitter, saline taste. It is soluble in water, and insoluble in alcohol. It is prepared by several methods: (a) By treatment of potassium chloride either with sulphuric acid or sulphur dioxide, air and water (Hargreaves Process); (b) By fractional crystallization of a natural sulphate ore; (c) From salt lake brines.

Its main uses are: Reagent in analytical chemistry, medicine, gypsum cements fertilizer for chloride-sensitive crops such as tobacoo and citrus alum manufacture, glass manufacture and food additive.

Potassium thiocyanate

Potassium thiocyanate, KCNS, is a colourless transparent, hygroscopic, odourless, crystalline substance having saline cooling taste. It is soluble in water, alcohol and acetone. It turns brown, green, blue when fused, white again on cooling. It is prepared by heating potassium cyanide with sulphur. It is moderately toxic by ingestion.

Potassium thiocyanate is used as a reagent in analytical chemistry; in the manufacture of sulphocyanides, thiorureas; in the printing and dyeing textiles, as a photographic restrainer and intensifier, in synthetic dyestuffs and in medicine.

Potassium thiosulphate

Potassium thiosulphate, $K_2S_2O_3$, is colourless crystalline substance. It occurs with varying proportions of water of crystallization. It is very hygroscopic, soluble in water, and insoluble in alcohol.
Potassium thiosulphate is an analytical reagent.

BIBLIOGRAPHY

1 Kirk, R.E.; Othmer, D.F.; *Encyclopedia of Chemical Technology;* 16, 361 (1968).

2 Ashmore, H.S.; *Encyclopedia Britanica;* 18, 321 (1962).

3 Crouse, W.H.; Eggenberger, D.I.; *McGraw-Hill Encyclopedia of Science and Technology;* 10, 530 (1960).

4 Law, M.D.; *Chamber's Encyclopedia;* 11, 121 (1959).

5 Snell, H.D.; Hilton, C.L.; *Encyclopedia of Industrial Chemical Analysis;* 17, 353 (1973).

6 Krishnamurthy, A.; *The Wealth of India ; Industrial Products;* Part 7, 42 (1971).

7 Van Thoor, T.J.W.; *Materials and Technology : Metals and Ores;* 1, 465 (1968).

8 Whiteley, M.A.; *Thorpe's Dictionary of Applied Chemistry;* 10, 134 (1950).

9 Young, L.E.; Petty, W.M.; *Chemistry for Progress;* 184 (1960).

10 Trotman-Dickenson, A.F.; *Comprehensive Inorganic Chemistry;* 1, 369 (1973).

11 Kraus, E.H.; Hunt, W.F.; Ramsdell, L.S.; *Mineralogy;* 468 (1959).

12 Sax, I.; *Dangerous Properties of Industrial Materials;* 1036 (1975).

13 Miller, B.F.; *The Modern Medical Encyclopedia;* 9, 1056 (1965).

14 Mark, H.F.; Gaylord, N.G.; *Encyclopedia of Polymer Science & Technology;* 1, 639 (1964).

15 National Fire Protection Association; *National Fire Codes;* 3, 49 (19)

16 Walters, S.L.; Miller, R.R.; *Ind. Eng. Chem., Anal. Ed.;* 18, 468 (1946).

17 Gilbert, H.N.; *Chem. Eng. News;* 26, 2604 (Sept. 6, 1948).

18 Mausteller, J.W.; Tepper, F.; Rodgers, S.J.; *Alkali Metal Handling and Systems Operating Techniques;* (1967).

19 Jackson, C.B.; and Warner, R.C.; *"Handling and Uses of the Alkali Metals," Advan. Chem. Ser.* 19, 169–177 (1957).

20 Going, L.H.; *J. Am. Oil. Chemists' Soc.;* 44, 414 A (1967).

21 Hawley, G.G.; *The Condensed Chemical Dictionery,* 9th Edition, pp. 709 – 719 (1977).

22 Mellor, J.W.; *A Comprehensive Treatise on Inorganic and Theoretical Chemistry,* 2 (1922).

23 Sidgwick, N. V.; *The Chemical Elements and Their Compounds,* 1 (1950).

24 Moeller, T.; *Inorganic Chemistry,* (1952).

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